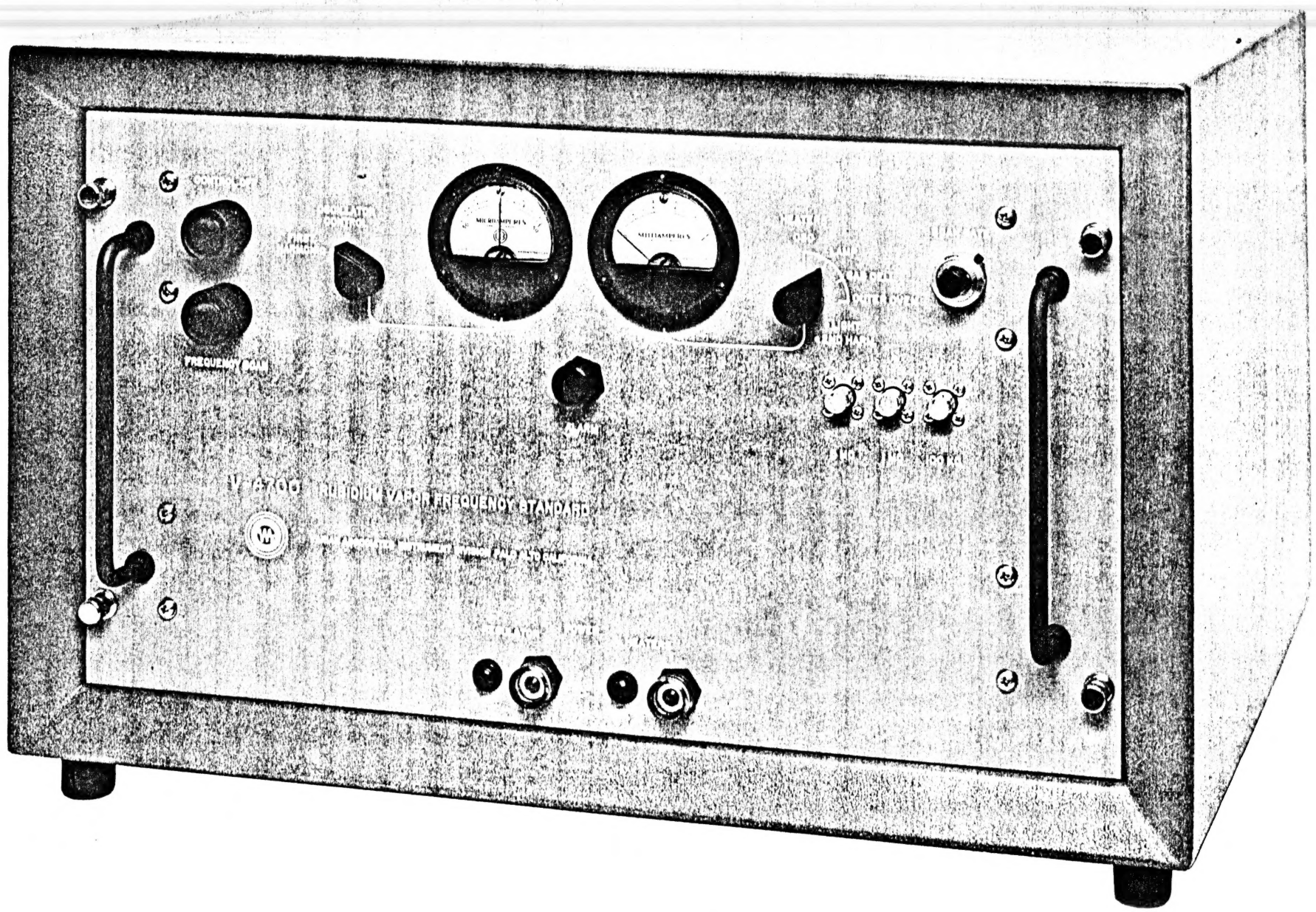


FIGURE 3-1. FRONT PANEL, V-4700A RUBIDIUM VAPOR FREQUENCY STANDARD

3.0 OPERATING INSTRUCTIONS

3.1 OPERATING CONTROLS AND METERING

3.1.1 V-4700A Rubidium Vapor Frequency Standard Front Panel (See Figure 3-1.)

3.1.1.1 Controls

Control	Function
CONTROL OFF	Breaks control loop by disconnecting the phase detector from the operational amplifier and shorting the integrating resistor associated with the operational amplifier.
FREQUENCY SCAN	Injects a current, controlled by the SCAN RATE control on the front panel, into the input of the operational amplifier. The operational amplifier integrates this current to give a voltage scan at its output. This scan is then applied to the control Varicap in the oscillator to provide a frequency scan.
SCAN RATE	This control injects zero current at a dial setting of about 500. Below 500 the OSCILLATOR CONTROL voltage will integrate upward with time. When used with the Rear Control MANUAL Frequency SET switch down, the SCAN RATE control becomes instead a direct fixed control on oscillator frequency.
REGULATOR	A circuit breaker on the input to the regulator.

HEATERS	A circuit breaker on the power to the heaters.

3.1.1.2 Meters

Meter Position	Function
HEATERS-OSC	Monitors the voltage across the heater winding in the crystal oscillator.
HEATERS-LAMP	Monitors the voltage across the heater winding in the lamp-filter cell package.
HEATERS-GAS CELL	Monitors the voltage across the heater winding in the cavity.
HEATERS-OUTER OVEN	Monitors the voltage across the heater winding in the outer oven. With 28 vdc bus voltage, the heaters are delivering full power at a meter reading about 0.85 full scale.
LIGHT	Monitors light intensity by means of a photocell located in the lamp package. In normal operation reads about half scale.
2ND HARMONIC	Monitors the second harmonic level at the output of the preamplifier, and is an indication of signal strength when the system is locked.
FIRST HARMONIC	Monitors the voltage at the output of the phase detector. This voltage is positive if the microwave frequency is above the hyperfine frequency and negative if it is below.

	When the instrument is locked this voltage is zero.
OSCILLATOR CONTROL	Monitors the voltage applied to the control Varicap in the 5 mc oscillator.
	At this point it should be mentioned that the phase detector, the operational amplifier, and the Varicap circuitry in the 5 mc oscillator all use a floating ground which is held +11.5 v above chassis ground. FIRST HARMONIC and OSCILLATOR CONTROL metering is relative to this floating ground.

3.1.1.3 Lights

Lights	Function
ALARM	This light turns on when the second harmonic drops below some preset level.
REGULATOR	This light turns on when the REGULATOR circuit breaker is closed and a voltage appears at the regulator output.
HEATERS	This light turns on when the heater circuit breaker is closed and heater voltage is available.

3.1.2 V-4760 Power Supply Front Panel
(See Figure 3-2)

3.1.2.1 Controls

Control	Function
AC	The AC switch switches the 60 cycle power to the Sola constant voltage transformer-

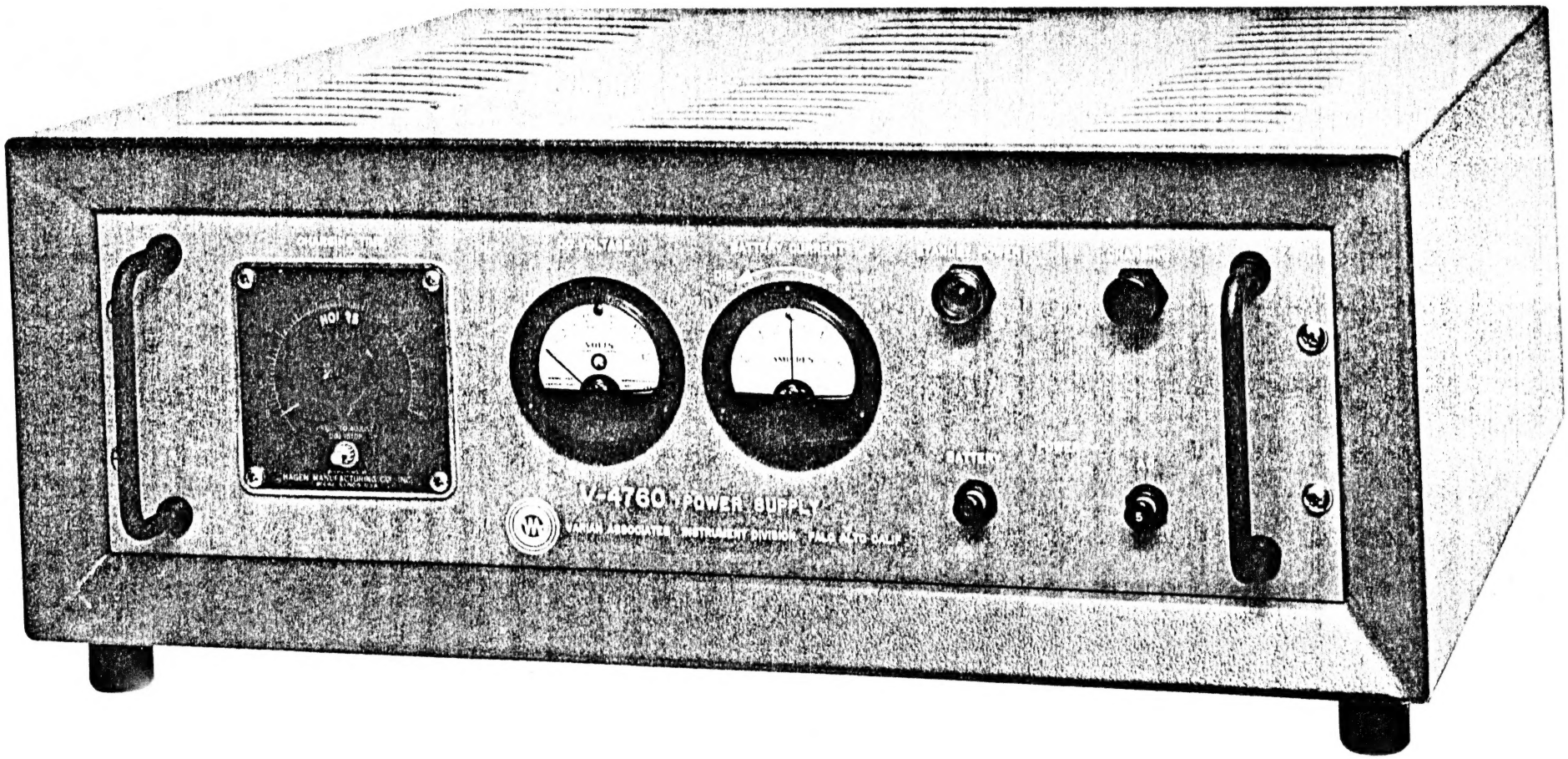


FIGURE 3-2. FRONT PANEL, V-4760 POWER SUPPLY

	rectifier primary power source.
BATTERY	When closed, the BATTERY switch places the standby batteries in parallel with the primary d-c power. The AC and BATTERY switches are all circuit breakers.
CHARGING TIME	When the CHARGING TIME timer is activated, the voltage on the d-c power bus is raised from its normal 28 v to 31 v. After the unit has been operated on nickel-cadmium standby batteries, it is recommended that the batteries be overcharged at 31 v for a time equal to the discharge time of the batteries. When the timer reaches zero, the d-c power bus voltage is dropped to its normal value.

3.1.2.2 Meter

Meter Position	Function
DC VOLTAGE	Meters the output voltage.
BATTERY CURRENT	Meters the current flow to and from the batteries.

3.1.2.3 Lights

Light	Function
STANDBY POWER	This light is on if standby batteries are used and the output disappears from the rectifier. It shows that current is being drawn from batteries.

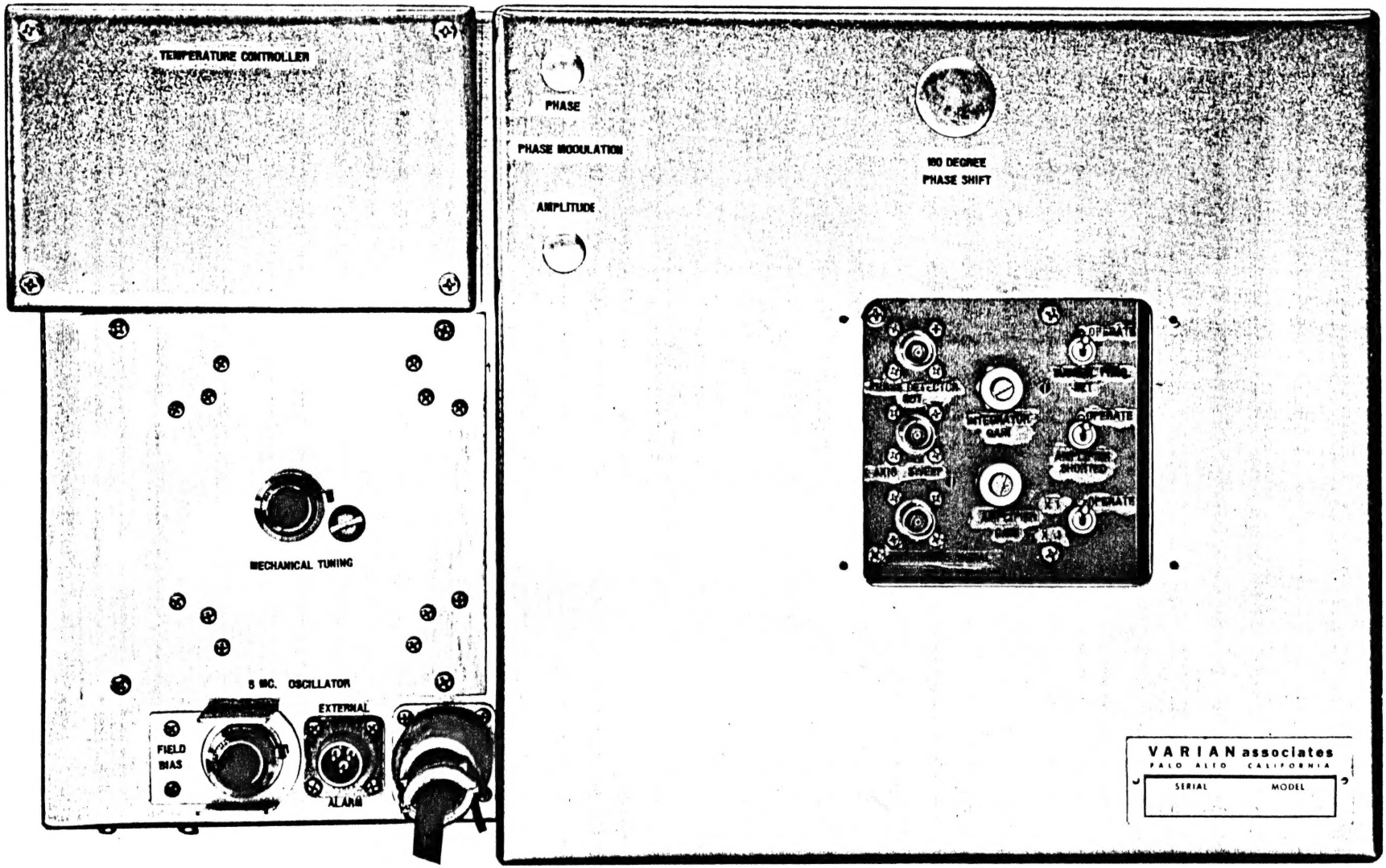


FIGURE 3-3. REAR VIEW, V-4700A FREQUENCY STANDARD

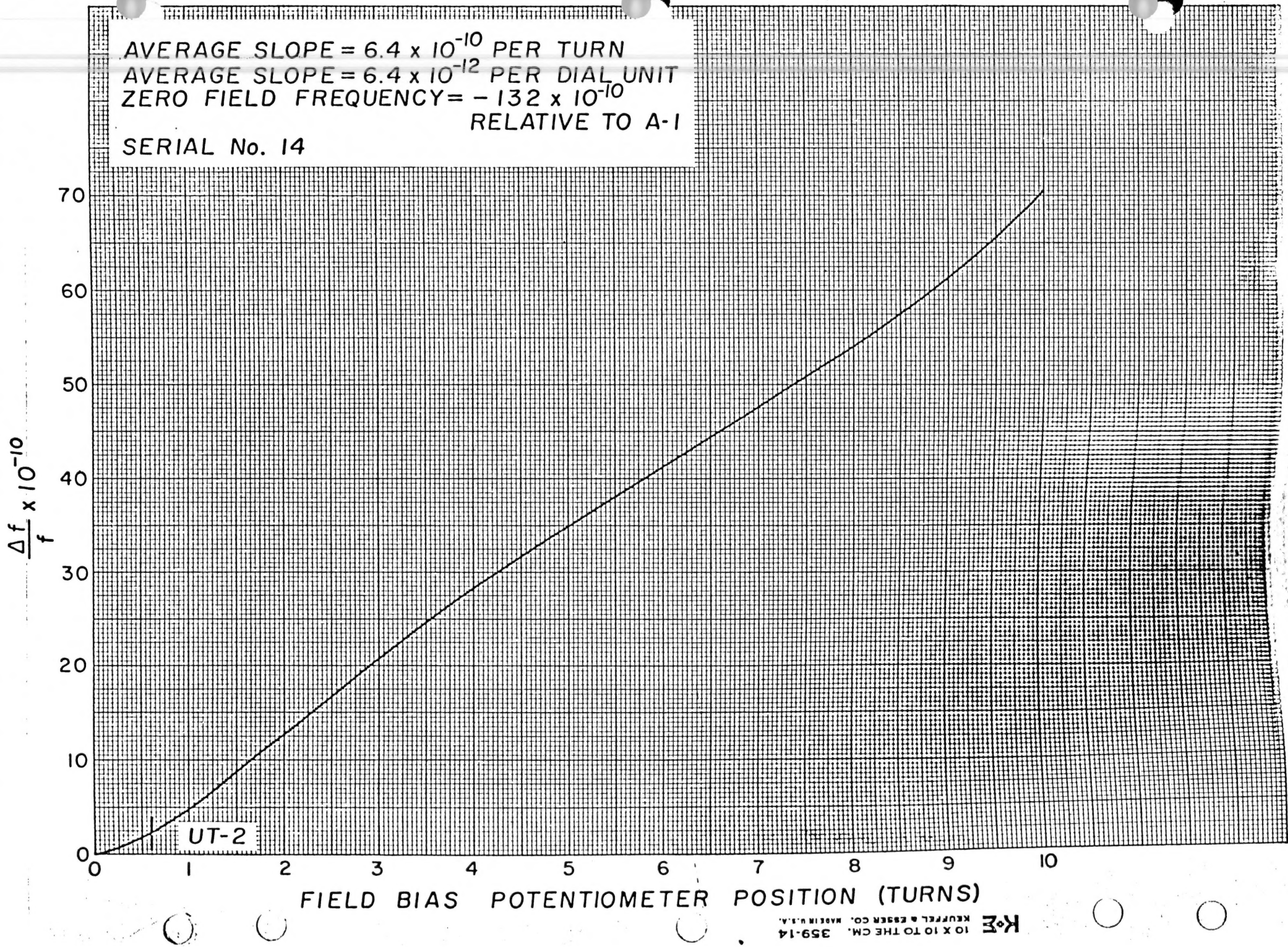
CHARGING	This light is on when the CHARGING TIME timer is used to raise the d-c bus voltage to 31 v.

3.1.3 V-4700A Rubidium Vapor Frequency Standard Controls, Adjustments, and Monitoring Points

3.1.3.1 Rear Controls (See Figure 3-3.)

Control	Function	Normal Position
OPERATE-MANUAL FREQ SET	In the MANUAL FREQ SET position the amplifier output is disconnected from the oscillator control Varicap and a voltage controlled by the SCAN RATE front panel control is applied directly in this Varicap. This voltage can be monitored at the OSCILLATOR CONTROL metering position.	Operate
OPERATE-AMPLIFIER SHORTED	In the AMPLIFIER SHORTED position the input to the filter amplifier is shorted.	Operate
ZERO DRIFT	This control is accessible through a hole in the side of the servo cover adjacent to the 5 mc oscillator. The AMPLIFIER SHORTED switch and the ZERO DRIFT adjustment are used together to remove offsets in the phase detector and operational amplifier. Set this switch to the AMPLIFIER SHORTED position. With the OPERATE- MANUAL FREQ SET switch in the OPERATE position, use the FREQUENCY SCAN push button and SCAN RATE	

	control to bring the OSCILLATOR control voltage near the middle of its range. Engage a small screwdriver in the ZERO DRIFT control and adjust it until the OSCILLATOR control voltage no longer drifts. If an appreciable drift exists initially, it may be necessary to recenter the meter with the FREQUENCY SCAN system several times before the adjustment is completed.	
X1 OPERATE -X.1	In the X.1 position the gain of the filter amplifier is reduced by a factor of 10. This position is used in the alignment of the instrument.	X1 Operate
AMPLIFIER GAIN.	This gives continuous control over the gain of the filter amplifier.	Maximum (full right)
INTEGRATOR GAIN	This provides a range of gain control on the operational amplifier (integrator) by varying the series input resistance.	Minimum (full left)
	AMPLIFIER GAIN and INTEGRATOR GAIN will be set at the factory. The normal positions listed above are approximations to the point where these controls will be set. These controls will be discussed later in Section 3.4.3.	
MODULATION AMPLITUDE, MODULATION PHASE INVERSION	MODULATION AMPLITUDE, MODULATION PHASE, AND PHASE INVERSION controls are accessible through holes in the back of servo cover.	


AVERAGE SLOPE = 6.4 x 10^-10 PER TURN
AVERAGE SLOPE = 6.4 x 10^-12 PER DIAL UNIT
ZERO FIELD FREQUENCY = -132 x 10^-10 RELATIVE TO A-1
SERIAL No. 14
UT-2
Δf/f x 10^-10
0
10
20
30
40
50
60
70
0
1
2
3
4
5
6
7
8
9
10
FIELD BIAS POTENTIOMETER POSITION (TURNS)
K&E
10 X 10 TO THE CM. 359-14
KEUFFEL & ESSER CO. MADE IN U.S.A.

VARIAN ASSOCIATES
Palo Alto, California
September 26, 1962

POTENTIOMETER SETTING (TURNS)	$\frac{\Delta f}{f} \times 10^{-10}$
.10	0
.20	.317
.40	.940
.60	2.09
.80	3.23
1.00	4.69
1.50	8.72
2.00	12.8
2.50	16.9
3.00	20.8
3.50	24.6
4.00	28.2
4.50	31.8
5.00	35.0
5.50	38.1
6.00	41.3
6.50	44.4
7.00	47.4
7.50	50.7
8.00	54.0
8.50	57.2
9.00	61.2
9.50	65.4
10.00	70.6

to reach the proper voltage. After the unit has been powered by the standby batteries, it is recommended that the batteries be overcharged, using the CHARGING TIME timer for a length of time equal to the discharge time on the batteries. Always check water level before and after each charge.

3.3 TURNING THE INSTRUMENT ON

The following instructions pertain to the operation of the V-4760 Standby Power Supply.

NOTE

IF OTHER SOURCES OF POWER
ARE USED CERTAIN OBVIOUS
CHANGES WILL BE REQUIRED.

Turn AC power on; the dc voltage should read 28 v. If standby batteries are used, turn the BATTERY switch ON. Turn the HEATER and regulator switches ON. Since the thermally controlled elements will be cold, the HEATER-OSC, LAMP, GAS CELL and OUTER OVEN should read full on. To increase heater power during initial warm-up, the CHARGING TIME timer may be set at approximately 1 hour. If this feature is used, do not turn BATTERY switch ON until the timer has turned itself OFF.

Switch the right hand meter to LIGHT. The lamp should turn on in about one minute and give a reading about half-scale.

After about one hour, the OSCILLATOR, LAMP, GAS CELL, and OUTER OVEN heater voltages should start decreasing, indicating the temperatures are approaching their proper value. At this point, a signal may be observed. Press the FREQUENCY SCAN button and use the SCAN RATE control to sweep the OSCILLATOR CONTROL voltage through its range. During this swing, the instrument should lock which will be indicated by a

reading on the 2nd HARMONIC meter. If second harmonic is of sufficient amplitude, at this time the ALARM light will also go OFF. It is to be expected that for a period of about an hour the signal will continue to grow as the lamp and gas cell reach internal equilibrium. In the same period of time, the crystal oscillator will reach internal equilibrium and the OSCILLATOR CONTROL voltage should be brought to zero with the MECHANICAL TUNING adjustment on the oscillator.

3.4 ADJUSTMENT OF CONTROLS

To adjust controls an oscilloscope should be used with connections made to the jacks on the rear of the instrument. Figure 3-5 shows oscilloscope trace of the PHASE DETECTOR output when MANUAL FREQuency SET is used. In Figure 3-5-A the microwave frequency is above

(A) (B) (C)

FIGURE 3-5

the hyperfine frequency; in Figure 3-5-B, the microwave frequency is below the hyperfine frequency; and in Figure 3-5-C, the two frequencies coincide which is the condition that exists when the system is locked. Figure 3-6 shows a RESONANCE SIGNAL when the system is locked.

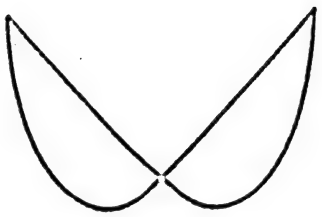


FIGURE 3-6

3.4.1 Modulation Controls

To adjust modulation controls observe the PHASE DETECTOR output on MANUAL FREQ SET, offset the microwave frequency from the hyperfine frequency by an amount which gives a phase detector output about one-half the maximum value obtainable. Adjust MODULATION AMPLITUDE control to nearly maximum the area under the oscilloscope trace. It is advisable to use an amplitude slightly less than that which gives maximum area. The front panel FIRST HARMONIC meter may be used as an aid in performing this operation. Adjust the MODULATION PHASE to bring the trace and retrace into coincidence; this gives maximum area upon the curve and maximizes the control voltage for a given frequency error. Figures 3-5-A and 3-5-C indicate correctly phased signals. Figure 3-7 indicates an incorrectly phased signal.

The PHASE DETECTOR output must be positive for the microwave frequency above the hyperfine frequency; this occurs for the SCAN RATE potentiometer below the value which these two frequencies coincide. If the sign of the PHASE DETECTOR output is incorrect, invert with the PHASE INVERSION switch.

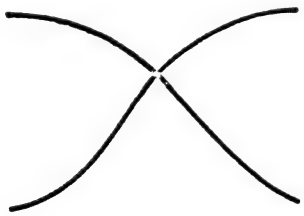


FIGURE 3-7

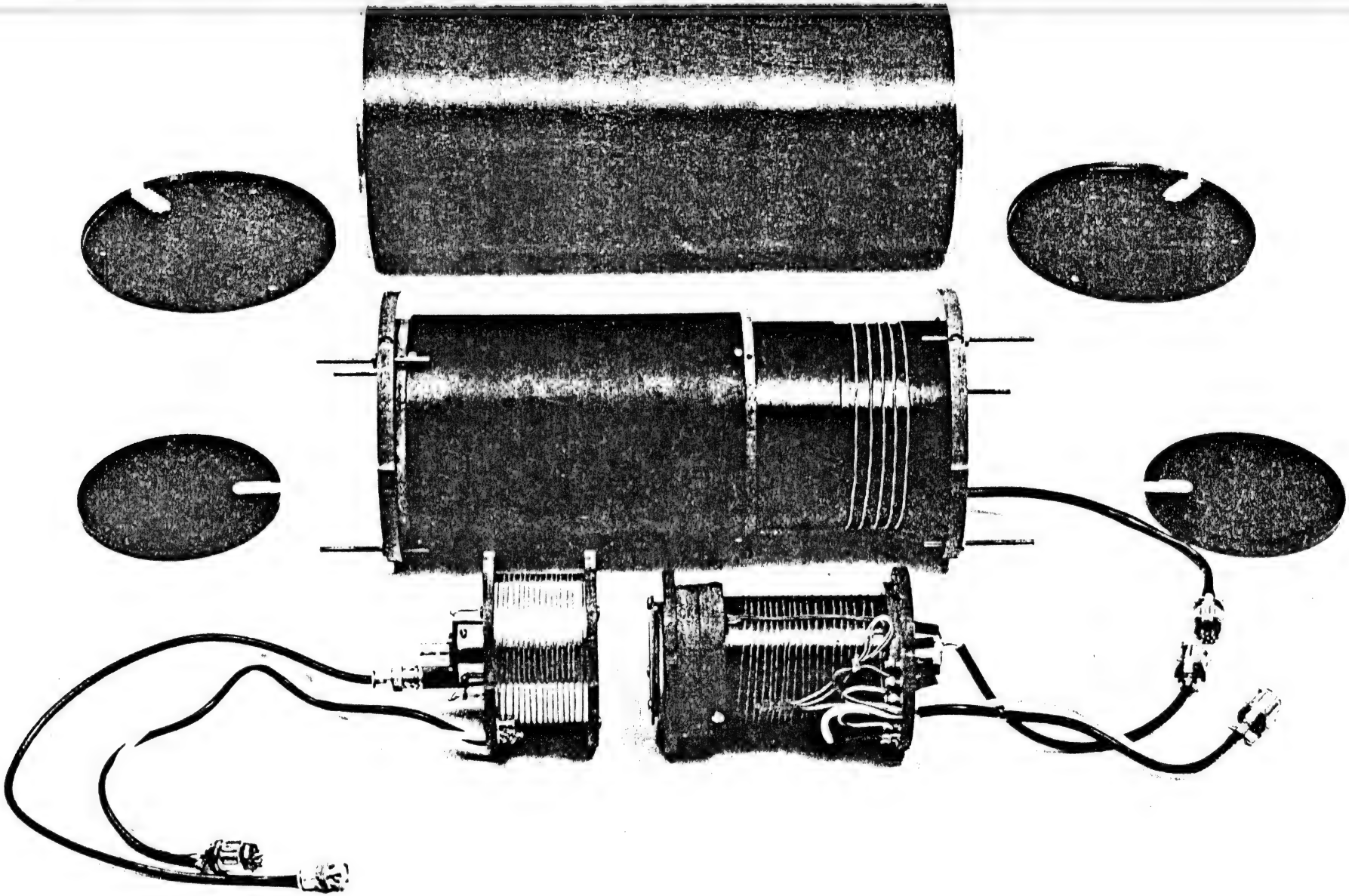


FIGURE 3-8. OPTICAL PACKAGE

3.4.2 Zero Drift

The procedure for using the ZERO DRIFT and AMPLIFIER SHORTED controls to remove phase detector and operational amplifier offsets has been discussed in Section 3.1.3.1. It is advisable, when it is not required that the instrument be in lock, to occasionally make this adjustment.

3.4.3 Amplifier and Integrator Gains

These two adjustments provide a means of controlling the loop gain of the frequency control system. Observe the PHASE DETECTOR output, use MANUAL FREQ SET and adjust the frequency to coincide with the hyperfine frequency. Adjust AMPLIFIER GAIN so the noise level at the PHASE DETECTOR output is 1.5 to 2.0 volts peak-to-peak. This then gives as high a gain as can be reasonably used without running into saturation, which occurs at 4 volts peak-to-peak.

Set INTEGRATOR GAIN at minimum value (full left) and lock the system. Increase INTEGRATOR GAIN until overshooting and control loop oscillations are noticed. Then reduce INTEGRATOR GAIN until overshooting disappears. This will set the loop gain roughly a factor of two below the value at which the loop will start oscillating. In some instances, because of a limited range of INTEGRATOR GAIN control, it may be necessary to reduce AMPLIFIER GAIN below the level set in the previous paragraph in order to stop loop oscillations.

3.4.4 Removal of the V-4700A from the Cabinet

Remove the two screws at the bottom rear of the instrument which clamps it to the bottom rails of the cabinet. Loosen the front panel screws and slide the unit forward out of the cabinet.

3.4.5. Adjustments in Optical Package

Figure 3-8 shows an exploded view with the cavity and lamp-filter cell package taken out of the outer oven. To remove the internal

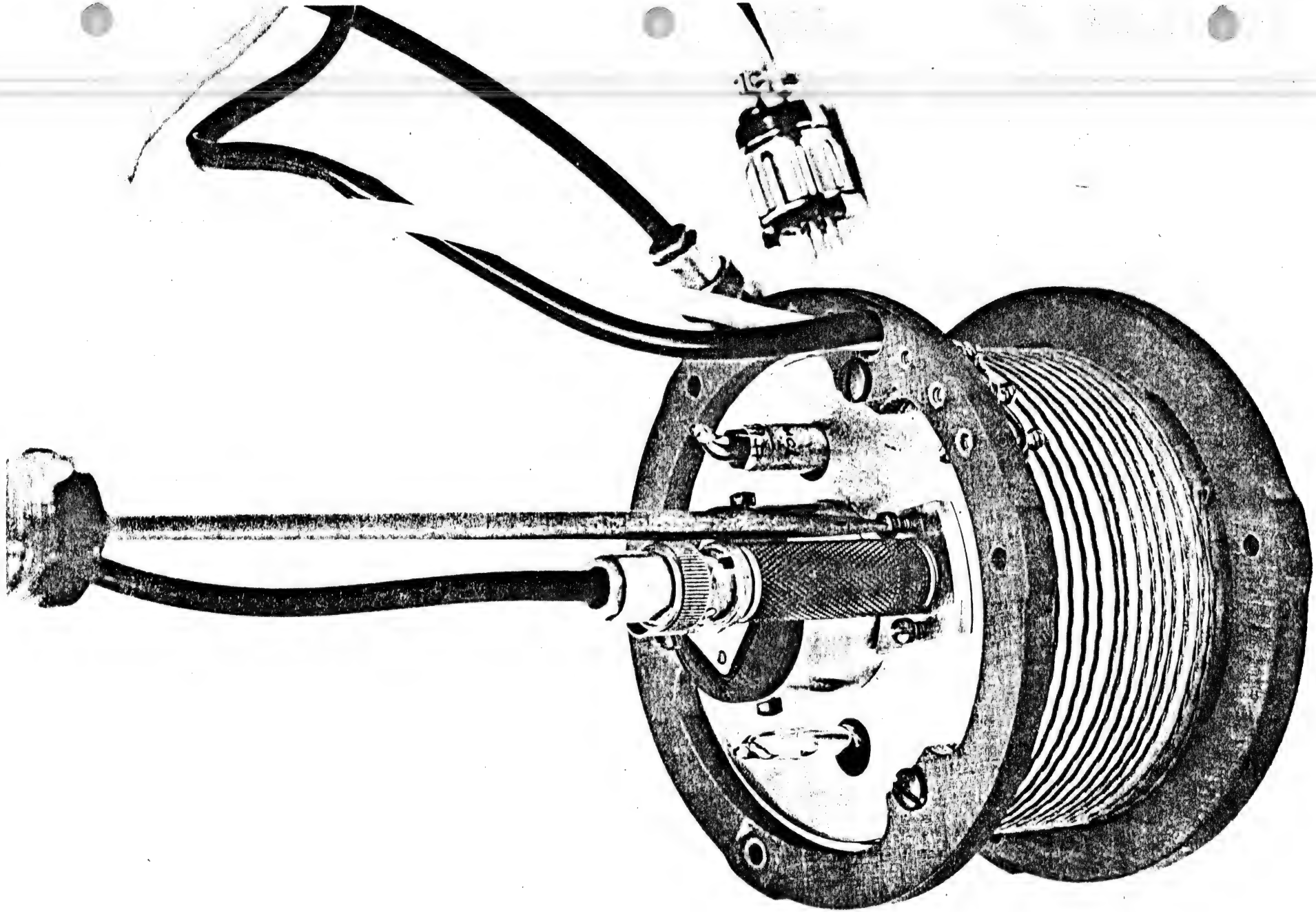


FIGURE 3-9. MICROWAVE POWER ADJUSTMENT

components, the end caps of the magnetic shield and outer oven must be removed. The cavity and lamp-filter cell package are held in place in the outer oven with tie rods. When replacing these assemblies, the tie rod nuts must be tightened securely to prevent any motion during shock, vibration, or acceleration of the instrument.

3.4.5.1 Adjustment of Microwave Power

The adjustment is made by adjusting the angle of the coupling loop in the cavity. Loosen the screws on the coupling loop locking plate as shown in Figure 3-9. Observe the PHASE DETECTOR output on an oscilloscope with MANUAL FREQ SET and the frequency slightly off resonance. Set gain at X.1 so amplifier saturation does not occur. As the coupling loop is rotated, changes in signal level and signal phase will be noted. Rotate coupling loop so a rather sharp minimum occurs in signal height. As the loop is rotated from this position and microwave power increases, the signal amplitude will increase with little phase shift. As the loop is further rotated, it will be observed that the signal height reaches a maximum value and considerable phase shift has now occurred. Set the microwave power by locking the loop with the two screws in the locking plate, at a level slightly below the value which gives the maximum signal. If required, adjust modulation phase as in section 3.4.1.

3.5 TEMPERATURE CONTROL ADJUSTMENTS

The temperature controllers are located on the rear of the main chassis. These controllers should normally require no adjustment. If for some reason they do, screwdriver adjustments are provided for temperature set points and loop gain in each controller. The left hand pot is the temperature control and the right hand pot is the gain control. Turn CW to increase both temperature and loop gain. The controllers are identified from top to bottom as follows: oscillator, lamp package, gas cell, and outer oven. The bottom board in the temperature control

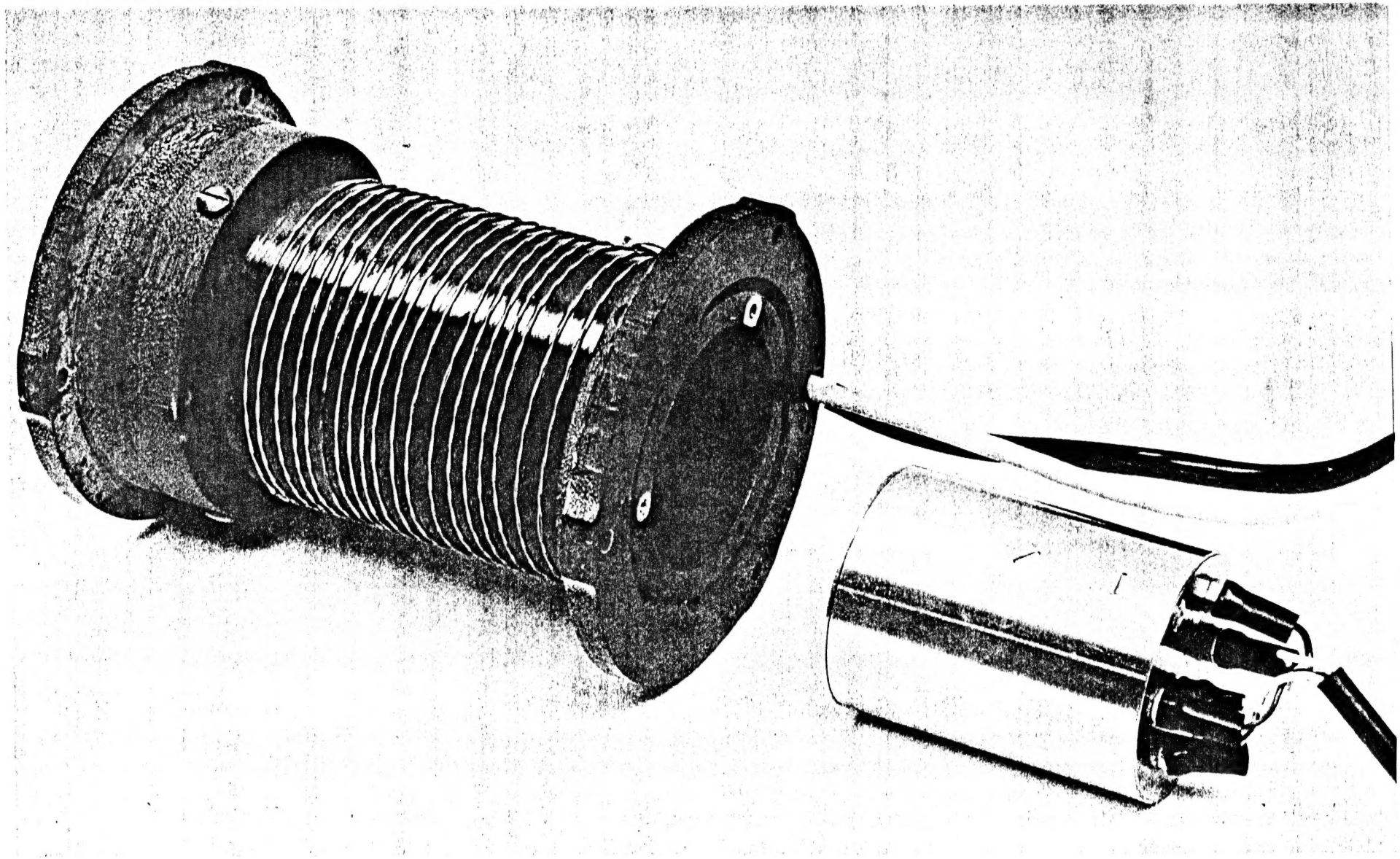


FIGURE 3-10. REMOVAL OF LAMP ASSEMBLY

package mounts the bridge excitation oscillator and phase detector driver circuits which are common to all four channels.

To make those temperature controller adjustments, the V-4700A must be removed from the case and the cover must be removed from the temperature controllers. WHENEVER THIS COVER IS REMOVED OR PUT ON, BE SURE ALL POWER IS TURNED OFF.

3.6 INTERNAL SERVO SYSTEM CIRCUITRY

Figure 3-11 shows the servo system with the cover removed. WHENEVER THIS COVER IS REMOVED OR PUT ON, BE SURE THE REGULATED POWER IS TURNED OFF.

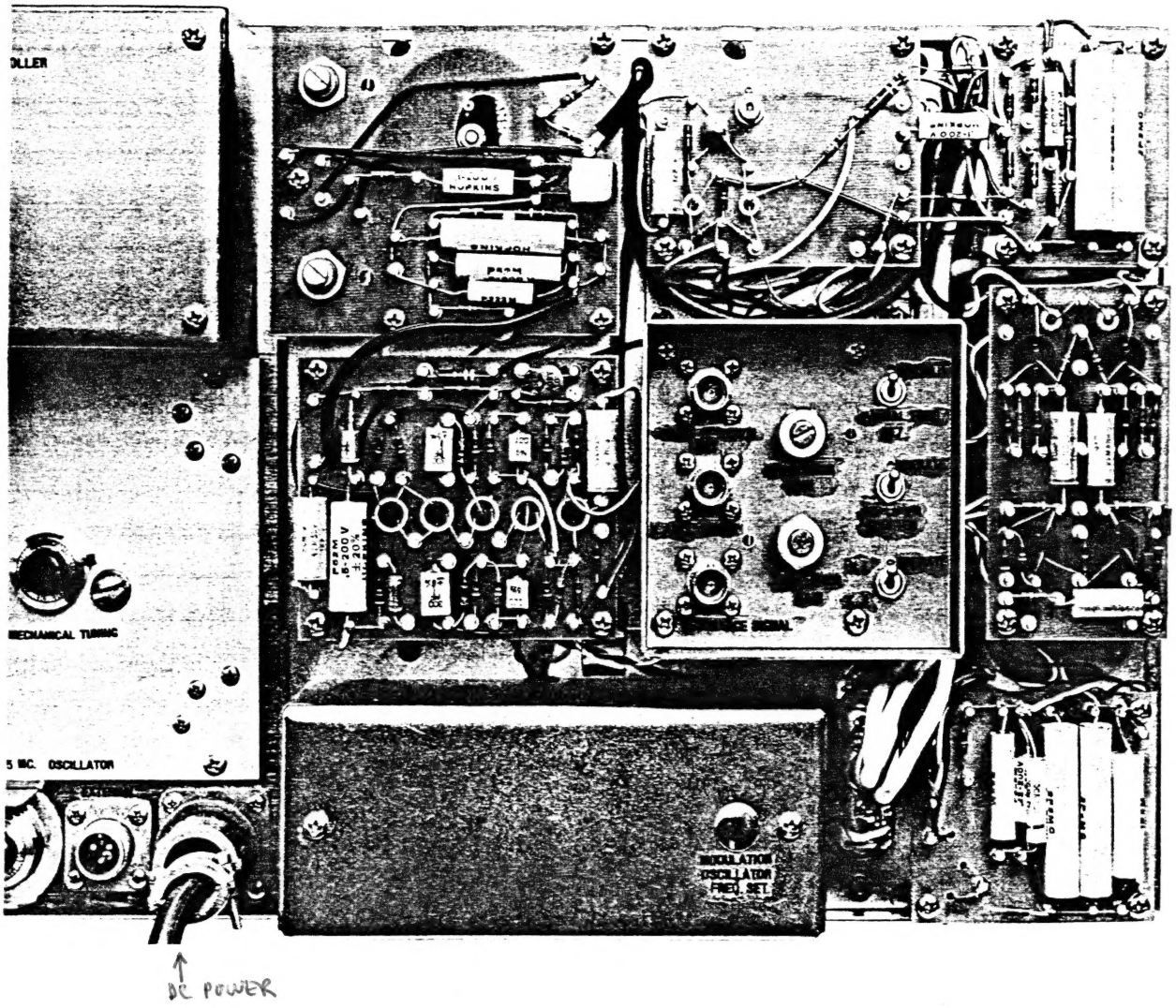
The various circuit boards of the servo system are labeled in this figure.

3.6.1 Adjustment of Modulation Oscillator and Second Harmonic Filter

The MODULATION OSCILLATOR and second harmonic bridged-tee filter have been factory adjusted to give very high second harmonic rejection. A need for adjustment will exist if a second harmonic signal is seen on the PHASE DETECTOR output when the system is locked. To do this the MODULATION OSCILLATOR FREQuency control, adjustable by a screwdriver through a hole in the internal MODULATION OSCILLATOR cover, and the bridged-tee variable resisor, which is the small trimpot on the second harmonic filter board, must be adjusted. To adjust the trimpot a long shank, narrow blade screwdriver is required. Adjust both controls until the second harmonic on the PHASE DETECTOR output is brought to zero.

3.6.2 Adjustment of 2nd Harmonic Meter and Alarm Light Sensitivity

These adjustments are made by screwdriver adjustments through small holes in the side of the main interior chassis, located in the rear of the cavity end of the optical package. The meter sensitivity and the alarm trip point are both increased by clockwise adjustment.



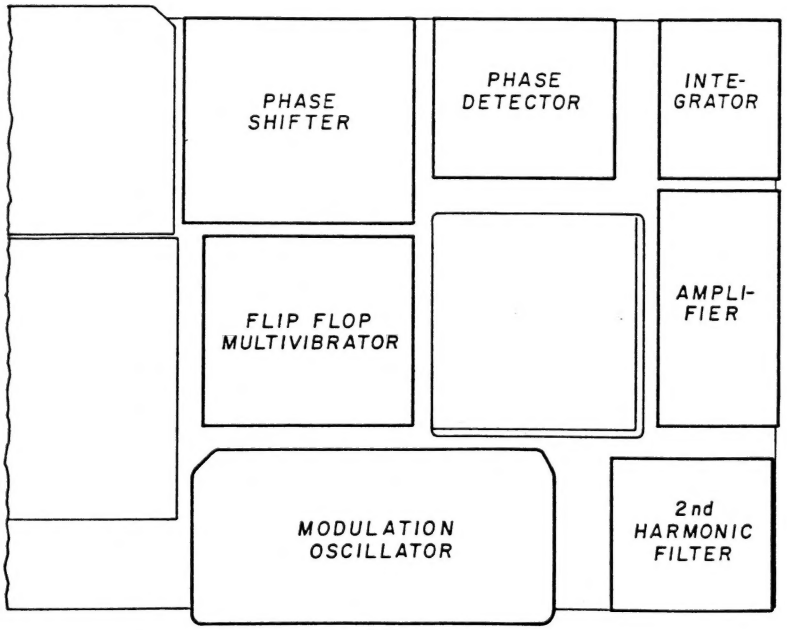


FIGURE 3-11. REAR VIEW, SERVO SYSTEM LAYOUT